Business ecosystem as the new approach to complex adaptive business environments

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Abstract

This paper discusses the concept of business ecosystem. Business ecosystem is a relatively new concept in the field of business research, and there is still a lot of work to be done to establish it. First the subject is approached by examining a biological ecosystem, especially how biological ecosystems are defined, how they evolve and how they are classified and structured. Second, different analogies of biological ecosystem are reviewed, including industrial ecosystem, economy as an ecosystem, digital business ecosystem and social ecosystem. Third, business ecosystem concept is outlined by discussing views of main contributors and then bringing authors' own definition out. Fourth, the emerging research field of complexity in social sciences is brought out due to authors' attitude to consider ecosystems and business ecosystems as complex, adaptive systems. The focal complexity aspects appearing in business ecosystems are presented; they are self-organization, emergence, co-evolution and adaptation. By connecting business ecosystem concept to complexity research, it is possible to bring new insights to changing business environments.

Keywords

Business ecosystem, complexity

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Introduction

The conceptual leap to be taken in this paper is to define the concept of business ecosystem. Many authors have something to say about business ecosystems but fail to give a definition for this concept. The lack of a precise definition causes confusion since concepts like industrial ecosystem and digital business ecosystem are used in related contexts. The concept has existed for over ten years, but in many writings it is still ill-defined and ambiguous. However, business ecosystem is a highly descriptive expression for the complex business environment which is the reality for most companies nowadays. The purpose of this paper is to compare different interpretations given for business ecosystem and to build a precise definition on this basis.

The theoretical background is drawn from the emerging paradigm of complexity. The study of complexity has gained a lot of attention in recent years. Its contribution to biology and other natural sciences has been widely acknowledged. The new wave of complexity research is trying to find applications in various fields, including social and economic systems. This paper explores complexity theory in the context of business ecosystems. Concepts applicable to business ecosystems would be self-organization, co-evolution, emergence, and adaptation.
The chosen research method is conceptual analysis. Data is gathered through a literature research, which takes into account latest books and articles written about business ecosystems and complexity. Research strategy includes comparison and assessment of different interpretations for business ecosystem, and finally formation and reasoning of our own interpretation.

Different Ecosystem Analogies

Biological Ecosystem

In order to find a formal definition for ecosystem a few dictionary definitions are checked first. According to The New Shorter Oxford English Dictionary (1993) biological ecosystem is “a system of organisms occupying a habitat, together with those aspects of the physical environment with which they interact”. This definition is quite abstract and thus despite its correctness not very useful. The Merriam-Webster Third New International Dictionary of the English Language (1986) defines biological ecosystem as “a community of living organisms with air, water and other resources”. This definition highlights the community aspect of a biological ecosystem. World Resources Institute (2000, 11) defines ecosystems in a quite similar way, just adding that ecosystems do change. World Resourves Institute (2001, 11) claims that “ecosystems are not just assemblages of species, they are systems combined of organic and inorganic matter and natural forces that interact and change.” These definitions are all clear and sound, but also lifeless, not giving us any picture of the complex dependencies between species and the continuous hum of life. It is also said that ecosystems are “the productive engines of the planet” (WRI 2000, 3).

Birth and evolution of an ecosystem is a path-dependent, chaotic process, which means that a small difference in starting values can cause great differences to results. Kauffman (1995, 211) states a question wondering how stable communities of species come together, and proclaims we do not know. The formation of an ecosystem is affected by certain attractors, which are the non-living components of the area where the ecosystem takes place. World Resources Institute expresses it in another way saying that each ecosystem “represents a solution to a particular challenge to life” (WRI 2001, 3). The same view is still visible in Kauffman’s thought that cells, ecosystems and economic systems are also “real equilibrium systems” and thus behave in ways that are their “own shortest descriptions” (Kauffman 1995, 22).

Biological ecosystems are divided into five main types or categories. They are grasslands, forests, agroecosystems, freshwater systems, and coastal ecosystems. (WRI 2000, 11) Distinguishing biological ecosystems is difficult, since usually there is no sharp border between different communities or habitats. However, as WRI puts it, “divisions between ecosystems are less important than the linkages between them”. All these systems are tightly knit into a global continuum of energy and nutrients and organisms - the biosphere. Concerning the structure of ecosystems Kauffman (1993, 255) states that natural ecosystems are not totally connected but “typically, each species interacts with a subset of the total number of other species; hence the system has some extended web structure”. Intuitively referring to the former information this web structure of species resembles a huge scale-free graph. One kind of scale-free graph is illustrated by Callaway (in Strogatz 2001, 271). In a scale-free graph there are some highly-linked nodes, which cause clustering of nodes in a way that makes us think of ecosystems in biosphere.

However, the structure of ecosystem is not everything. As evolving systems, “ecosystems are dynamic, constantly remaking themselves, reacting to natural disturbances and to the competition among and between species” (WRI 2000, 11). Because an ecosystem must be all the time ready to answer to changes outside and inside it, there must be a variety of distinct species to ensure that at least part of them can cope with any new situation. Thus diversity of species influences ecosystem stability and it also supports essential ecological services (WRI 2000, 14). This requisite variety in species and connections between them is noticed also by Kauffman within ecosystem simulations. He gets excited about the question: “In fact, the results of our simulations suggest that the very highest fitness occurs precisely between ordered and chaotic behaviour! How can we tell? We can see how deeply ecosystems are in the ordered regime by seeing how readily they “freeze” into evolutionary stable strategies” (Kauffman 1995, 228). He also states that “each ecosystem is itself on the boundary between sub- and supracriticality” and thus “trading their stuff they collectively produce leads to a supracritical biosphere”, which is even more complex (Kauffman 1995, 129). The complexity of an ecosystem is also seen in the appearance of system level phenomena, “the particular package of services and products that each ecosystem yields”, rising from the “complex, local interaction of the physical environment and the biological community” (WRI 2000, 11).

Industrial Ecosystem

Industrial ecosystem concept was originally presented in Scientific American by Frosch and Gallopoulos (1989). The basic idea is environmental protection by the means of nature. Industrial ecosystem is an analogue of biological ecosystem, where all material is recycled infinitely and efficiently. Such an ideal is hardly attained in any industrial operations but the change of habits of both manufacturers and consumers would help us to maintain our standard of living without devastating the environment (Frosch & Gallopoulos 1989, 145).

This change means that different parties should "co-operate by using each other's waste material and waste energy flows as resources" (Korhonen et al. 2001, 146). The virgin material and possibly also virgin energy inputs, as well as the waste and emission outputs of the system as a whole, are reduced because waste is used to substitute for the virgin material and energy sources. (Korhonen 2001, 146)

Korhonen et al. (2001, 146) give us and example of an industrial ecosystem's different material and energy flows in Finnish forest industry. They have divided the flows into four groups consisting of wooden matter, nutrients, carbon and energy. As regards to energy, the aim is reducing the use of non-renewable fossil fuel (Korhonen et al. 2001, 150).

There are three major objectives in any industrial ecosystem considering matter:
1) minimum input of virgin material
2) efficient use of virgin material
3) minimum and harmless waste (Korhonen et al. 2001, 148).

Thus, the goal in industrial ecosystem analysis is to bring the principles of sustainable development into all kinds of industrial operations.

Economy as an Ecosystem

Rothschild (1990, xi) states that "a capitalist economy can best be comprehended as a living ecosystem. Key phenomena observed in nature – competition, specialization, co-operation, exploitation, learning, growth, and several other – are also central at business life." According to Rothschild (1990, xii) the basic mechanisms of economic change are remarkably similar with those found in nature. The main difference is speed, which is quite a lot faster within economic change.

Rothschild calls his view of economics bionomics. "Economic development, and the social change flowing from it, is not shaped by society's genes, but by its accumulated technical knowledge. Technology, not people, holds center stage in this view of economic life." (Rothschild 1990, xiii)

Rothschild draws a variety of analogies between economic and biological phenomena. "Every organism is defined by the information in its genes, but a living thing also is defined by its relationships to its prey, competitors, and predators. In the same way, an organization is defined by its technology and by its associations with its suppliers, competitors, and customers. From a bionomic perspective, organisms and organizations are nodes in networks of relationships. As time passes and evolution proceeds, some nodes are wiped out and new ones crop up, triggering adjustments that ripple across each network. Constrained by its key relationships, each organism and each organization is held in its niche, pursuing the same goal – the genetic or technological information it carries." (Rothschild 1990, 213)

In Rothschild's analogy firms serve as biological organisms and industries as species. "Like the organisms and species that make up the global ecosystem, the world's firms and industries have spontaneously coevolved to form a vast living ecosystem." (Rothschild 1990, 337) In

Rothschild's ecosystem, efficiency is rewarded by survival. Inefficiency, on the other hand, is punished by extinction (Rothschild 1990, 224).

In a way, Rothschild's view of economy as an ecosystem is an application of systems theory. The global economy is seen as a system, in which there is interaction among the participants.

Digital Business Ecosystem (DBE)

DBE is discussed in this paper, because the term resembles business ecosystem in a bewildering way, even though these two concepts do not have much in common on the implementation stage. Digital business ecosystem is a European Union funded environment, which provides a structure, where software coded by European SMEs can act like organisms in an ecosystem. The main goal is to enhance possibilities of SMEs to compete with larger software houses. Nachira proclaims that it produces an extraordinary competitive advantage for a region if small organisations within it adopt digital business ecosystem early (Nachira 2002, 21).

According to a discussion paper written by Nachira, a digital business ecosystem is constructed when the "adoption of Internet-based technologies for business" is on such a level that "business services and the software components are supported by a pervasive software environment, which shows an evolutionary and self-organising behaviour" (Nachira 2002, 10).

Ecological standpoint is present in DBEs in such a way that it is considered to be a "digital environment" populated by "digital species". These digital species can be software components, applications, services, knowledge, business models, training modules, conceptual frameworks, laws, etc. (Nachira 2002, 12). The environment enables species to behave like species in natural world, to interact, express an independent behaviour, evolve or become extinct if the amount of individuals of a species is not sufficient. Simpler species may form compositions, which allows more complex species to appear. (Nachira 2002, 12)

There are a couple of derivatives of DBE; sector-specific ecosystem and local business digital ecosystem. Sector-specific ecosystem appears when a particular sector of business life adopts the digital ecosystem and applications for that sector will appear. Local business digital ecosystems are instances of sector-specific ecosystems which are implemented at local level. (Nachira 2002, 10)

Social Ecosystem

According to Mitleton-Kelly (2003, 23), organizations are always co-evolving within a social ecosystem. In Mitleton-Kelly's social ecosystem "each organisation is a fully participating agent which both influences and is influenced by the social ecosystem made up of all related businesses, consumers, and suppliers, as well as economic, cultural, and legal institutions." (Mitleton-Kelly 2003, 30)

In defining a social ecosystem, the key point is interdependence among the entities within it (Mitleton-Kelly 2003, 31). One important phenomenon within a social ecosystem is co-evolution. Mitleton-Kelly (2003, 29) emphasises that co-evolution cannot happen in isolation, but it must happen within an ecosystem.

Mitleton-Kelly (2003, 31) argues that functioning like a social ecosystem is a critical success factor for any organisation. “When firms and institutions cease to function like a community or social ecosystem, they may break down.” (Mitleton-Kelly 2003, 31)

Social ecosystem thus consists of firms and institutions, and not of people as the word ‘social’ could imply. Mitleton-Kelly’s research is concentrated on complexity in socioeconomic systems, and thereby she claims that phenomena of complex systems can be found also in social ecosystems.

Business Ecosystem

Moore’s Business Ecosystem

Moore defines business ecosystem as “an economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world.” According to Moore, a business ecosystem includes customers, lead producers, competitors, and other stakeholders. The key to a business ecosystem are leadership companies, “the keystone species”, who have a strong influence over the co-evolutionary processes. Moore states that these are just metaphors which can clarify certain issues and help understanding them. (Moore 1996, 9, 25, 26)

In another instance Moore’s definition is somewhat different. Business ecosystem is an “extended system of mutually supportive organizations; communities of customers, suppliers, lead producers, and other stakeholders, financing, trade associations, standard bodies, labor unions, governmental and quasigovernmental institutions, and other interested parties. These communities come together in a partially intentional, highly self-organizing, and even somewhat accidental manner.” (Moore 1998, 168) First definition highlights interaction within a business ecosystem, while the second one emphasises decentralised decision-making and self-organisation.

Moore suggests that the term ‘industry’ should be replaced with the term business ecosystem, since nowadays you cannot divide economic activities under specific industries. Business ecosystems are based on core capabilities, which are exploited in order to produce the core product. In addition to the core product, a customer receives “a total experience” which includes a variety of complementary offers. (Moore 1996, 15)

The life-cycle of a business ecosystem can be divided into four stages. In the birth stage it is essential to do more than just satisfy customers. In the expansion stage the scale-up potential of the business concept is tested. In the leadership stage the business ecosystem reaches stability and high profitability. The final stage, self-renewal or death, is caused by the threat of rising new ecosystems. (Moore 1993, 76) Moore does not, however, say anything about what happens after successful self-renewal.

Moore (1996, 18) suggests that the major difference between ecological and social systems is the role of conscious choice. Animals do choose their habitats, mates and behaviour. In the economic world, on the other hand, policy-makers, managers, and investors spend a lot of time understanding the situation and contemplating the possible outcomes of different choices.

Although Moore claims that the word industry should be replaced with the word business ecosystem, it is apparent that Moore's business ecosystem is closer to the concepts of cluster and value network. These concepts are analysed in detail in (Peltoniemi 2004).

Iansiti and Levien's Business Ecosystem

Also Iansiti and Levien (2004) use business ecosystem as an analogy, which can help to describe and understand certain issues. "We found that perhaps more than any other type of network, a biological ecosystem provides a powerful analogy for understanding a business network. Like business networks, biological ecosystems are characterized by a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival. And like business network participants, biological species in ecosystems share their fate with each other. If the ecosystem is healthy, individual species thrive. If the ecosystem is unhealthy, individual species suffer deeply. And as with business ecosystems, reversals in overall ecosystem health can happen very quickly." (Iansiti & Levien 2004, 8-9) Features of a business ecosystem include fragmentation, interconnectedness, cooperation and competition (Iansiti & Levien 2004, 35).

According to Iansiti and Levien (2004, 46) there are three critical success factors of a business ecosystem. First, productivity is a very basic factor which, at some point, will define the success of any kind of business. Second, any business ecosystem should be robust. Robustness in natural ecosystems means capabilities of surviving when shocks from inside or outside the ecosystem threaten to destroy it. In business life this means drawing competitive advantage from many sources and having the ability to transform when the environment changes. Third, a business ecosystem should have the ability to create niches and opportunities for new firms. This requires a change in attitudes from protectionist to co-operative.

Iansiti and Levien (2004) introduce four different roles that organizations can take in business ecosystems. Keystones are the kind of companies which serve as the enablers and which have a great impact on the whole system. However, they constitute a small number of the system. Niche players, on the other hand, make up the largest mass of the business ecosystem. Dominators and hub landlords are the kind of organisations which attract resources from the system but do not function reciprocally.

It should, however, be pointed out that there are differences between natural and business ecosystems. First of all, in business ecosystems the actors are intelligent and are capable of planning and seeing the future. Second, business ecosystems compete over possible members. Third, business ecosystems are aiming at delivering innovations, where natural ecosystems are aiming at pure survival. (Iansiti & Levien 2004, 39)

Power and Jerjian's Business Ecosystem

Power and Jerjian are against the linear way of thinking. In their book "Ecosystem: Living the 12 Principles of Networked Business" they state that you cannot manage a business on its own, but you have to manage an entire ecosystem (Power & Jerjian 2001, 3). Power and

Jerjian claim that ecosystem constitutes of integrated electronic business (2001, 118) and their formal definition for a business ecosystem is ”a system of websites occupying the world wide web, together with those aspects of the real world with which they interact. It is a physical community considered together with the non-living factors of its environment as a unit” (2001, 13). It is possible to recognize the aspects of biological ecosystem in this definition, perceiving that organisms are substituted by websites and their habitat is WWW instead of any physical location. One must say that this definition is a bit obscure. It gives us an idea that websites would build up a physical community and the real world would be the source of non-living factors in their environment. This is maybe too much in contradiction with our perceptions of the world. Maybe it would be better in line with their other statements to say that many businesses are so highly dependent on WWW that it is their virtual habitat where web sites are their expressions.

In natural ecosystems energy is passing through different forms. In business ecosystems resources, which include capital, are analogous to energy (Power & Jerjian 2001, 263). Thus, they should be used efficiently for the ecosystem to prosper. Ecological selection happens on the macro level and a crucial part of fitness is the ability to adapt to new channels of information, “the strands of telecommunication connect our communities and inevitably cause the gradual birth of new businesses and the death of old ones” (Power & Jerjian 2001, 6). Power and Jerjian use Heathrow airport as an example of good exploitation of telecommunication technology. There software is the thing that runs the airport. They draw an analogy between the software of Heathrow airport and the nervous system of a biological organism (Power & Jerjian 2001, 99). Despite their strong emphasis on technological connectedness, they admit that becoming a networked business does not just mean getting on the internet but rather fundamentally changing everything that the company does (Power & Jerjian 2001, 247).

According to Power and Jerjian’s thinking, there are four stakeholders to any enterprise, which should be taken into account: communities of shareholders, employees, businesses and customers (2001, 18). The ecosystem standpoint should be taken while considering the advantages of cooperation. In nature different species help each other to produce wealth and prosperity to whole community. Power and Jerjian produce one example about this phenomenon, namely a coral reef, where the structure for the whole community is created by coral polyps. In the same way business ecosystem is often built on one single company, who is highly connected. (Power & Jerjian 2001, 289)

Other Contributors

Gossain and Kandiah (1998) build on Moore’s business ecosystem emphasizing the role that internet can have in the networked information economy. They want to extend Moore’s concept by recognizing the importance of creating value for customers through the provision of additional information, goods and services (Gossain & Kandiah 1998, 1). Gossain and Kandiah include only partners and suppliers to business ecosystem and say that the “connectivity between them is the engine at the heart of the whole system” (Gossain & Kandiah 1998, 2). They see business ecosystem basically similar to integrated value chain, added that business ecosystem emphasizes close symbiotic relationships between organizations, evolvement of those relationships and the significance of brand (Gossain & Kandiah 1998, 4).

They proclaim that the business ecosystem concept changes especially the nature of business-to-business relationships (Gossain & Kandiah 1998, 5), where the electronic commerce makes the big difference (Gossain & Kandiah 1998, 2). However, their contribution is not focal, mainly because instead of developing business ecosystem concept on its own terms, they are mixing old concepts like value chain and e-commerce and call it a business ecosystem. Their view is also a very customer-centred and technical, and thus flat. There is no explanation, why their approach should be described as an ecosystem, instead of with some well-established concept.

Lewin and Regine (1999, 207) for their part state that a business ecosystem is a network of companies each occupying a place on its own landscape of possibilities, and each landscape being coupled to many others: those of competitors, collaborators, and complementors. Due to interconnectedness, changes in the landscape of one company cause changes in the landscapes of other members of the business ecosystem. They also recommend for companies in complex environments, where co-opetition is present, to base their strategy on co-evolution (Lewin & Regine 1999, 208). This brings our thoughts to general complexity concepts.

Complexity concepts in Business Ecosystem

In the following sections we illustrate how different complexity aspects appear in business ecosystems. The reasoning why to consider business ecosystems as complex systems is made in other publications (Vuori 2004, Peltoniemi 2004).

Complexity

According to the Santa Fe Institute, complexity refers to "systems with many different parts which, by a rather mysterious process of self-organization, become more ordered and more informed than systems which operate in approximate thermodynamic equilibrium with their surroundings". On the other hand, "complex systems contain many relatively independent parts which are highly interconnected and interactive". (Cowan 1994, 1, 2) Ecological systems, the brain and the global economy are all examples of complex systems (Brown 1994, 419).

The relationship between systems theory and complexity is somewhat ambiguous. They, however, have certain differences. "Complexity builds on, and enriches systems theory by articulating additional characteristics of complex systems and by emphasising their inter-relationship and interdependence." (Mitleton-Kelly 2003, 25) One could say that complexity includes systems theory.

A complex system is "one whose properties are not fully explained by an understanding of its parts". (Lewin 1999, x) This view emphasises the idea that reductionist approach can not reveal the dynamics which arise from the interaction between the parts of a complex system. This implies that in any research on complex systems, one should not study the parts without understanding the whole. According to Lewin and Regine (1999, 198), understanding organizational dynamics within companies and in the web of economic activity among them is one of the most important avenues of study in the field of complexity science. Next we are going to review relevant complexity concepts, such as self-organisation, emergence, co-evolution and adaptation.

Self-organization

Self-organization has not been defined unambiguously in literature. Thus, the definition must be drawn from the features and functions that are reported relating to self-organization. Mitleton-Kelly suggests that self-organization concerns ability of complex systems to create new order and coherence. She refers to Kauffman's view on spontaneous order; he calls it self-organization, which is one of the key characteristics of complex systems. (Mitleton-Kelly 2003, 40) Mitleton-Kelly has also said that self-organization is a process, where there is no external or internal leader, who sets goals or controls the system, but the events occur spontaneously and due to local interactions (Mitleton-Kelly 2004).

Anderson (1999, 221) claims that self-organization is a process where "pattern and regularity emerge without the intervention of a central controller." Goldstein's thoughts are practically the same since he defines self-organization as "a process…, whereby new emergent structures, patterns, and properties arise without being externally imposed on the system" (in Choi et al. 2001, 354).

Kauffman sees self-organization in relation to attractors. "Dynamical attractors "box" the behaviour of a system into small parts of its state space, or space of possibilities. Hence attractors literally are most of what the system does. It is in the boxing of behaviour into small parts of state space which constitutes much of the self-organization we shall encounter." (Kauffman 1993, 174)

Here self-organization is defined as a process in which novel structures or features arise in a system without the intervention of an outside or inside controller. Self-organization is an ongoing process since it will never have completed its final outcome. Novelty is the contribution of self-organization and it can be specified in various ways in different systems. The lacking of an outside or inside controller is the key to self-organization. It is the "self" that organizes.

Self-organization appears in business ecosystems very perceivably. The formation of a business ecosystem is a process, where participants are gathered voluntarily and without external or internal leader. Goals are set in local interactions, where companies negotiate and create new order. To be honest, there may be some control and incentives set by government, but in general companies are free to create the kind of structures they prefer. This evolvement is continuing, new connections are created all the time and old ones are dissolved.

Emergence

Emergence, self-organization, evolution and adaptation are closely linked to each other, which may cause confusion of the individual significance of each concept. Frankly, emergent properties are the result of self-organization, while adaptation links these properties to the environment, and evolution concerns their long-term achievements. As Mitleton-Kelly (2003, 40) expresses it, "emergent properties, qualities, patterns, or structures, arise from the interaction of individual elements; they are greater than the sum of the parts". She also states that "emergence is the process that creates new order together with self-organization"

(Mitleton-Kelly 2003, 40). Mitleton-Kelly sees that the potential to create new order as the most important feature of complex evolving systems (Mitleton-Kelly 2004).

According to Smith & Stacey (1997, 83) emergence "means that the links between individual agent actions and the long-term systemic outcome are unpredictable". According to Phan (2004) the Santa Fe Institute sees emergence as "a property of a complex adaptive system that is not contained in the property of its parts". The idea of emergence, that something comes out of nothing, is at the very least questionable. However, emergence has been studied also in mathematics and it has been demonstrated convincingly in the behaviour of non-linear equations and systems of equations (see e.g. Mouck 1998).

Casti finds emergence as a "surprise-generating mechanism dependent on connectivity"; "this refers to the way the interactions among system components generates unexpected global system properties not present in any of the subsystems taken individually" (Casti 1997, 91). The idea is basically the same as in previous definitions. There is still something, which could be sharpened and it is the objectivity in terms of recognizing this phenomenon. If emergence is defined by unexpectedness, it raises a question about subjective observer, who expects something to happen and something not to happen. This problem is present with some other definitions as well, because they mention unpredictability as an aspect of emergent phenomena.

A business ecosystem is always more that the sum of its parts. The result of interactions between different units is something, which no one of those units could produce by oneself. This is especially visible in R&D, where the result is consisted by the contribution of many factors.

Co-evolution

According to Bechtold (1997, 194) "self-organization means not only emergent order and self-generation but also coevolution with the greater environment". Bateson defines co-evolution "as a process in which interdependent species evolve in an endless reciprocal cycle – in which changes in species A set the stage for the natural selection of changes in species B – and vice versa." (in Moore 1993, 75)

Pagie and Mitchell (2004) suggest that co-evolution can happen with one or two populations. In the first case co-evolution shapes the individual fitness of the members of the population. In the second case the fitness of individuals is shaped by their behaviour in the context of the individuals of the second population. The latter can be described as "host-parasite" or "predator-prey" co-evolution.

Merry's (1999, 272) definition of co-evolution is not restricted to biology: "When the change in fitness of one system changes the fitness of another system, and vice versa, the interdependency is called co-evolution. Co-evolution is the evolutionary mutual changes of species (or organizations) that interact with each other."

According to Agiza et al. (1997, 985) co-evolution is associated with negative and positive interactions. Negative interactions mean, for example, predation and competition while positive interactions include mutualism and sharing. Roos and Oliver (1999, 287) give an example of co-evolution. The ongoing battle between police and organized criminals in developing new technologies for preventing or committing crimes is a co-evolutionary struggle.

Co-evolution appears in business ecosystems as the evolution of one company affecting the evolution of other companies. An example of that is the classical case of microprocessors and software. While microprocessor producers develop more efficient processors, the software producers quickly make use of the new opportunities and the software becomes heavier, which causes pressure to develop even more efficient processors. Also strategic changes of one company affect strongly to possibilities of other companies in its ecosystem. This is why managers should consider the broad impact of their decisions over the whole ecosystem.

Adaptation

Adaptation is a familiar concept already from Darwin's "Origin of Species". According to Holland (1995, 9) "in biological usage adaptation is the process whereby an organism fits itself to its environment". Merry defines adaptation as climbing peaks of higher fitness (Merry 1999, 258).

According to Holland (1992, 159), adaptation generates "structures of progressively higher performance". Holland (1992, 4) suggests that there are three components associated to adaptation: the environment, the adaptive plan, and a measure of performance. Adaptive plan does not mean a plan of the direction of development. It is rather a testing plan, a tool for defining the measure of performance. The measure of performance, on the other hand, is usually called fitness. Adaptation can be criticized for the passive role of environment. Adapting always means adapting to something, and it incorporates the thought that the adapting unit is not capable of having an effect on its environment. This is why some authors, including Mitleton-Kelly, use rather solely concepts of evolution and co-evolution.

The whole ecosystem adapts to the external constraints. For example governmental restrictions, taxes and tariffs are those constraints, which are set by the other party and are not very likely to change by co-evolution. When the environment changes, a business ecosystem adapts to changed conditions by emergence, co-evolution and self-organization.

Conclusions

Discussion

Based on this review, the ecosystem analogy has been widely used for describing different kinds of structures and processes. These analogies emphasize different aspects of biological ecosystem and are applied in different fields. They can offer insights for using the ecosystem analogy but they can not be drawn together to form a theory of ecosystem analogies in social sciences and economics. All of these analogies serve as tools for understanding a system, whether biological, economic or social. It is also important to discuss, how far an analogy may be stretched. At some point a metaphor or an analogy will break. This is why Mitleton-Kelly (2003, 25) claims, that complexity in social systems should be studied on their own right and not as analogies from biological systems. Lewin and Regine (1999, 198) state that "businesses do not merely resemble natural ecosystems, they share some fundamental properties". This implies that instead of using metaphors and analogies, one should elevate the analysis to the level of fundamental mechanisms.

Economy as an ecosystem and social ecosystem are the closest analogies to business ecosystem, and can thus be used as sources of ideas for forming a theory for business ecosystems. The problem of drawing lines between ecosystems was raised while defining natural ecosystem. This problem is also present in outlining business ecosystems. It requires thorough understanding of the question in hand before it is possible to define the system and its environment. For the business ecosystem researcher, the boundaries can be set according to what is relevant in the context of the object of the study and the questions that are to be answered.

Treating business ecosystems as complex adaptive (or complex evolving) systems, it is possible to understand the principles of their formation, evolution and interdependence in a broader context and exploit the research made in other sciences. This area requires much more research, but it could bring valuable insights for managers in complex environments.

Definition of Business Ecosystem

As a conclusive definition we consider a business ecosystem to be a dynamic structure which consists of an interconnected population of organizations. These organizations can be small firms, large corporations, universities, research centers, public sector organizations, and other parties which influence the system.

In different texts, business ecosystem is defined either consisting of several organizations or of only one organization. In the latter, individual organization should operate as an ecosystem, in order to survive. We define business ecosystem to contain a population of organizations.

If we follow the principles of complexity business ecosystem should be self-sustaining. This means that no government interventions would be needed in order to survive in local or global markets. Business ecosystem develops through self-organization, emergence and co-evolution, which help it to acquire adaptability. In a business ecosystem there is both competition and cooperation present simultaneously.

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